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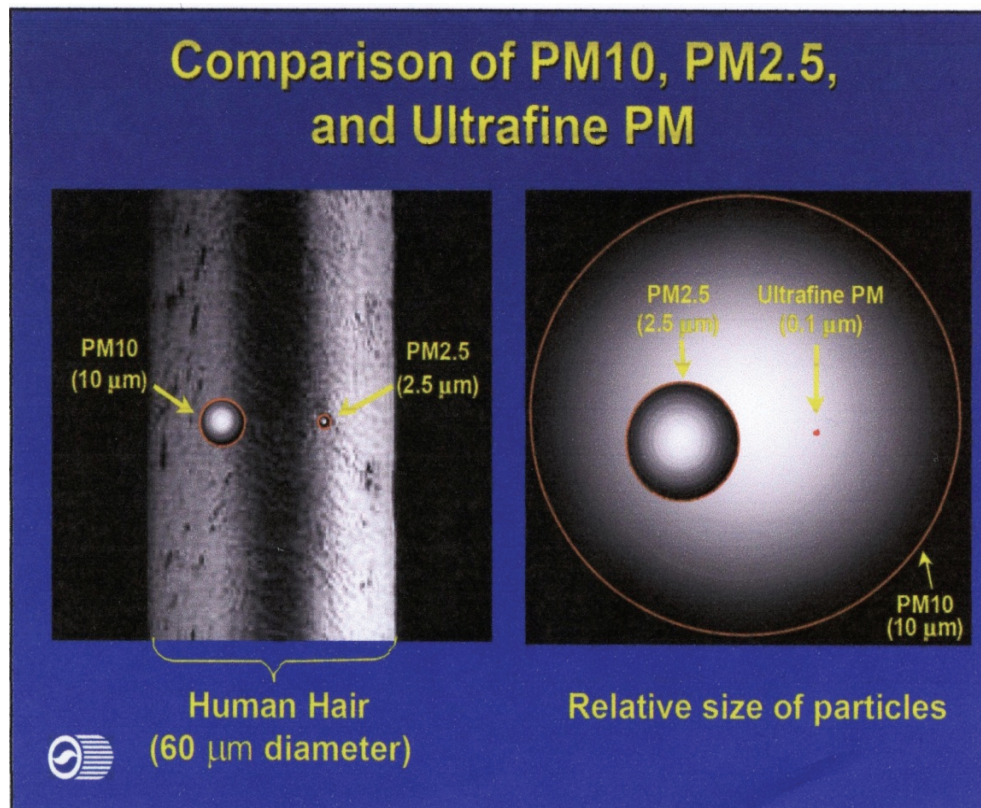
Particulate Matter

Particulate Matter Overview

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What Is Particulate Matter (PM)?

Particulate matter (PM) consists of very small liquid and solid particles suspended in the air. These particles can penetrate into the lungs and bloodstream and cause serious impacts on human health. The term "PM" encompasses a very diverse assortment of tiny particles which differ in terms of their formation, their chemical properties, size, mass, toxicity, and the way they behave in the atmosphere. PM₁₀ includes particles smaller than 10 microns in diameter. (One micron equals one-millionth of a meter; i.e. 10^{-6} . PM_{2.5} includes finer particles smaller than 2.5 microns in diameter. Particles with a diameter between 2.5 and 10 microns are sometimes referred to as "coarse particles". The figures below illustrate how very small these particles are.



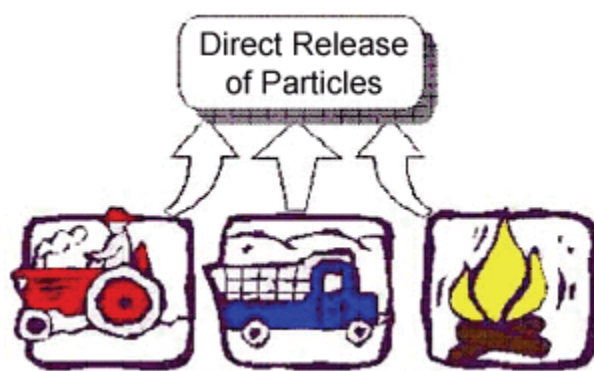
Ultrafine PM

The smallest particles, with a diameter of 0.1 microns or less, are referred to as ultra-fine PM (UFPM). Whereas larger particles dominate in terms of PM mass, UFPM dominates in terms of the

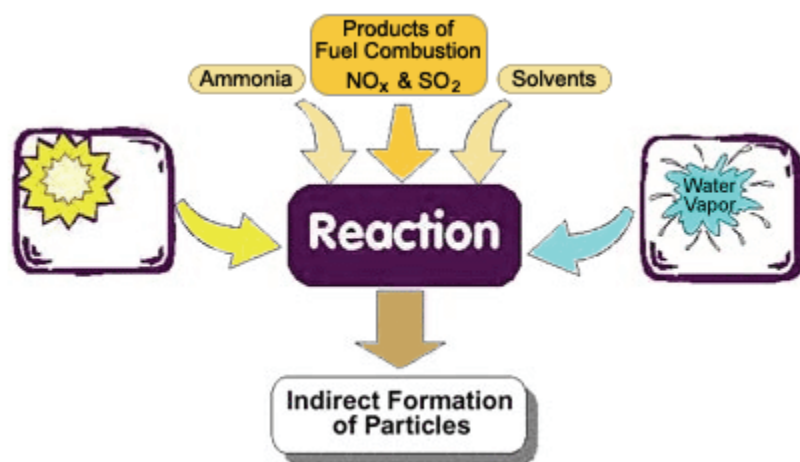
number of particles (particle count) and total surface area of the particles. UFPM is primarily a by-product of fossil fuel combustion. There is growing concern about the potential health impacts of UFPM because the particles are capable of penetrating very deeply into the body and organs. To date there are no State or national air quality standards for UFPM, nor any requirements to monitor ambient concentrations of UFPM. Instruments to measure UFPM have only recently become available. The Air District's Advisory Council has been investigating UFPM, and presented recommendations regarding UFPM to the Air District Board of Directors on December 7, 2011. The Air District will work to enhance its technical capabilities to analyze and monitor UFPM, and to stay abreast of the latest UFPM research, in the coming months.

PM Sources & PM Formation

Ambient PM is made up of particles that are emitted directly, such as soot and fugitive dust, as well as secondary particles that are formed in the atmosphere from reactions involving precursor pollutants such as oxides of nitrogen (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOCs), and ammonia (NH₃). Secondary PM and combustion soot tend to be fine particles (PM 2.5), whereas fugitive dust is mostly coarse particles.



Directly-emitted particles come from a variety of sources such as cars, trucks, buses, industrial facilities, power plants, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood.



Other particles are formed indirectly when gases produced by fossil fuel combustion in motor vehicles, at power plants, and in other industrial processes react with sunlight and water vapor. Many combustion sources, such as motor vehicles and power plants, both emit PM directly and emit precursor pollutants that form secondary PM. Ammonium nitrate and ammonium sulfate are the principal components of secondary PM.

The Air District has analyzed PM in the Bay Area, using filters that trap ambient PM measurements and speciation analysis to determine the major PM sources and their approximate contributions to Bay Area PM concentrations. On winter days when the Bay Area experiences peak ambient PM

concentrations, the largest single source of PM_{2.5} is wood burning. Emissions of direct-emitted PM and PM precursors from motor vehicles and other mobile sources (construction and farm equipment, trains, aircraft, and ships) account for nearly half the total PM during winter peak periods. [A copy of the report is available here](#) (438 k PDF, 48 pgs).

The dangers of PM

PM has negative impacts on public health, as summarized below. It also reduces visibility, damages buildings and structures, and causes adverse impacts to ecosystems, vegetation, and water quality. Certain types of PM, especially black carbon, also contribute to climate change.

Human Health

The air we breathe contains many minute particles, so small that they are invisible to the human eye. When we breathe, we inhale these tiny particles into our respiratory system (the airway and lungs). The particles can travel deep into the lungs, enter the bloodstream, and penetrate into cells. Smaller particles can penetrate deepest, causing the greatest harm. Research indicates that some types of PM, such as diesel PM (emissions of particulate matter from diesel engines), are especially harmful. However, scientists are still trying to identify which types and sources of particles are most hazardous to human health.

Health effects can result from both short-term and long-term exposure to PM pollution. Exposure to particulate pollution is linked to increased frequency and severity of asthma attacks. Exposure to PM can also trigger heart attacks and cause premature death in people with pre-existing cardiac or respiratory disease. People most sensitive to particulate pollution include infants and children, the elderly, and persons with existing heart and lung disease.

Many scientific studies have linked short-term exposure to PM to a series of significant health problems, including:

- aggravated asthma
- increases in respiratory symptoms like coughing and difficult or painful breathing
- chronic bronchitis
- decreased lung function
- heart attack
- premature death

Air District staff analyzed the health impacts of air pollution on Bay Area residents in preparing the Bay Area 2010 Clean Air Plan (see Appendix A of the Plan). *[insert link to 2010 CAP: <http://www.baaqmd.gov/Divisions/Planning-and-Research/Plans/Clean-Air-Plans.aspx>]* This analysis found that fine PM is the air pollutant which imposes the greatest burden on public health, and that exposure to PM accounts for more than 90% of premature mortality related to air pollution in the Bay Area. In addition, in fall 2011 Air District staff issued a report entitled *Health Impact Analysis of Fine Particulate Matter in the San Francisco Bay Area*.

Studies show that long-term exposure to diesel PM is associated with increased risk of lung cancer. In 1998 the California Air Resources Board took action to classify diesel PM as a toxic air contaminant. [Analysis](#) performed by the Air District found that diesel PM is responsible for over 80 percent of the total cancer risk from toxic air contaminants in the Bay Area.

Visibility impairment

PM is the major cause of reduced visibility (haze) in the United States, including both urban and rural areas. Poor visibility can impact quality of life, as well as potentially deter tourism in cities, as well as places like Yosemite Valley and the Grand Canyon where millions of visitors come every year to take in the views.

Aesthetic damage

Certain types of PM, such as black carbon (soot), can stain and damage building facades and other materials. This is a particular concern in the case of historically or culturally significant objects buildings, and monuments, and statues. Cleaning these landmarks can be expensive and time-consuming.

Atmospheric deposition

Relatively large particles (PM₁₀) generally remain suspended in the air for short periods of time (minutes or hours). PM₁₀ particles can travel as little as a hundred yards or as much as 30 miles. In contrast, because smaller particles are lighter, PM_{2.5} can remain suspended in the air for days or weeks, and can travel hundreds of miles before settling out. Depending on the chemical composition of the particles and where they are deposited, the ecological impacts of PM deposition can include:

- acidification of lakes and streams
- disturbing the nutrient balance in coastal waters and large river basins
- depleting the nutrients in soils
- damaging sensitive forests and farm crops

Climate Change

Particulate matter may also play an important role in terms of climate change. Some types of PM, such as aerosols that contain sulfate, scatter sunlight back to space, thus cooling the atmosphere. However, some other types of particles contribute to global warming. Black carbon or "soot", a type of PM produced by incomplete combustion of fossil fuels or biomass, has been identified as a significant contributor to climate change. When black carbon accumulates on snow or sea ice, it decreases the ability of the surface to reflect sunlight. By absorbing sunlight, black carbon accelerates the melting of glaciers and polar icecaps, one of the most dramatic examples of how man-made emissions are changing the global climate.

Climatologists are still working to better understand the effects of various particle types and the net effect of PM on global climate change. The **Intergovernmental Panel on Climate Change's (IPCC)** Fourth Assessment Report states that overall, man-made particulates (excluding the effect of black carbon on snow or ice) create a net cooling effect. Regardless of their overall impact on the climate, however, man-made particulates are still harmful to human health. The climate impacts of various types of PM are summarized in the table below.

Type of Aerosol	Cooling Agent	Warming Agent	Direct Effect	Indirect Effect	Source
Sulfates	X		Reflects sunlight	Increases reflectivity of clouds	SO ₂ emissions from fossil fuel-burning
Black carbon		X	Absorbs sunlight	Decreases reflectivity of polar regions	Incomplete combustion of fossil fuels
Ammonium nitrate	X		Reflects sunlight	Increases reflectivity of clouds	Agriculture (fertilizer, animal waste), combustion (NO _x)

PM conditions in the Bay Area

National standards: As shown in the table below, the Bay Area currently attains the national annual average and 24-hour standards for PM₁₀, and the national annual average standard for PM_{2.5}. U.S. EPA significantly tightened the national 24-hour PM_{2.5} standard from 65 µg/m³ (micro-grams per cubic meter) to 35 µg/m³ in 2006. Based on air quality monitoring data for the 2006-2008 period, which showed the Bay Area exceeding the revised standard by a small margin, EPA designated the Bay Area as non-attainment for the 24-hour national PM_{2.5} standard in December 2009. However, since that time, Bay Area PM_{2.5} levels have declined. Although the Bay Area is still officially designated as non-attainment, monitoring data for 2008-2010 shows that the Bay Area met the 24-hour national PM_{2.5} standard during this period.

State standards: California's air quality standards are the most stringent and health-protective standards in the nation; the California standards are designed to provide additional protection for those segments of the population who are most sensitive to the effects of air pollution. Currently the Bay Area, like virtually all of California, is designated as nonattainment for the State PM₁₀ standard. The Bay Area, like most urban areas, is also designated as nonattainment for the State PM_{2.5} standard.

	California Standard (µg/m³)	Bay Area Status CA Standard	National Standard (µg/m³)	Bay Area Status Nat. Standard
PM ₁₀ - Annual	20	Nonattainment	None	N/A
PM ₁₀ - 24-hour	50	Nonattainment	150	Attainment
PM _{2.5} - Annual	12	Nonattainment	15	Attainment
PM _{2.5} - 24-hour	None	N/A	35	Nonattainment

PM Planning Activities

See the [PM Planning](#) page for information on the District's current PM planning activities.

Efforts to reduce PM

Although the Bay Area does not yet attain all national and State PM standards, we have made major progress in reducing PM levels over the past 20 years. In response to concern about the public health impacts of PM, the Air District and the California Air Resources Board have been taking strong action to reduce emissions of directly-emitted PM, as well as PM precursors, from key emission sources, as described below.

Reducing PM Emissions from Mobile Sources

Motor vehicles are a major source of PM emissions. In addition, diesel PM has been classified by the Air Resources Board (ARB) as a toxic air contaminant. ARB adopted a [Diesel Risk Reduction Plan](#) in October 2000. To implement this plan, ARB has adopted a series of regulations to require cleaner (ultra-low sulfur) diesel fuel, to restrict idling of diesel engines, and to reduce emissions from both old and new on-road and off-road diesel engines (trucks and buses, cargo-handling equipment, construction equipment, ships, etc).

To accelerate the introduction of cleaner engines, the Air District implements a variety of incentive programs that help fleet operators offset the cost of purchasing low-emission vehicles, re-powering old polluting heavy duty diesel engines with cleaner, lower-emission engines, and installing emission control devices that reduce emissions of PM and NOx. These incentives are available for a wide variety of on-road and off-road equipment. To protect children, one program focuses specifically on reducing emissions from school buses.

BAAQMD PM Reduction Regulatory Program

In addition to these incentive programs, the Air District is implementing a comprehensive regulatory program to reduce PM, as described below.

Rules & Regulations

The Air District implements a number of regulations and programs to reduce PM emissions. These include rules limiting direct PM emissions from open burning of agricultural and non-agricultural waste, controlling dust from earthmoving and construction/demolition operations, limiting emissions from various combustion sources such as cement kilns and furnaces, and reducing PM from activities that generate dust or smoke. In addition, the Air District also adopts and enforces rules that limit emissions of PM precursors such as NOx and SO2 from power plants, industrial facilities, and other combustion sources, and volatile organic compounds (VOCs) from petroleum refineries, coatings and solvents, product manufacturing, fuel storage, transfer and dispensing activities, and many other industrial and commercial facilities.

SB 656 / PM Implementation Schedule

In 2003 the California Legislature enacted Senate Bill 656 (codified as Health and Safety Code section 39614) with the objective of reducing public exposure to PM10 and PM2.5 and accelerating progress toward attainment of State and national PM10 and PM2.5 standards. SB 656 required ARB to develop a list of the most readily-available, feasible, and cost-effective control measures to reduce PM. To comply with SB 656, the Air District reviewed the list of 103 potential PM control measures prepared by ARB and developed a Particulate Matter Implementation Schedule which was adopted by the Air District's Board of Directors in November 2005. All measures identified in the Air District's PM Implementation Schedule have been fully implemented. This includes adoption of regulations to reduce PM emissions from stationary internal combustion engines (Regulation 9-8) in July 2007, and commercial broiling operations (Regulation 6-2) in December 2007, as well as the residential wood-burning regulation described below.

Wood-Burning Programs

Residential wood burning is the single largest source of PM2.5 during the winter months, the period when the Bay Area experiences its highest PM2.5 levels. In July 2008, the Air District Board of Directors adopted Regulation 6, Rule 3: Wood-burning Devices to reduce harmful wood smoke emissions. This rule prohibits the use of any wood-burning devices, such as fireplaces, woodstoves, or pellet stoves, when the Air District issues a winter Spare the Air health advisory. The rule also places restrictions on visible emissions, bans the burning of garbage, plastics, and other unsuitable materials, and prohibits the sale and installation of non-EPA-certified wood-burning devices in new construction or re-models of homes in the Bay Area.

The Air District's program to reduce emissions from wood-burning devices such as fireplaces, wood stoves and heaters include the following:

- Wintertime [Spare the Air](#) alerts that notify Bay Area residents, via email or text messages, not to burn wood on cold, stagnant winter evenings that create conditions for increased PM levels.
- The Air District's [model wood burning ordinance](#) has been adopted by many Bay Area cities and counties to further reduce wood smoke impacts in their community.

The Air District conducts an annual wintertime survey on the days after a wintertime Spare the Air advisory in order to better understand public attitudes and behavior with respect to wood-burning.

Reducing Population Exposure to PM

To protect public health, the Air District has also been working to analyze and reduce population exposure to PM and other harmful pollutants. The Air District's efforts to reduce population exposure to PM and to toxic air contaminants include:

- The [Community Air Risk Evaluation \(CARE\)](#) program
- The Air District's revised [CEQA guidelines](#) for reviewing the air quality impacts of new development projects pursuant to the California Environmental Quality Act include "risk & hazards" thresholds for PM_{2.5}, and
- The Air District is working with local cities to develop [Community Risk Reduction Plans](#), with the initial efforts focused on the cities of San Francisco and San Jose

WHAT YOU CAN DO

Individuals, businesses, and other organizations can take actions to reduce PM emissions and the potential impacts of particulate matter. Examples include:

- Reduce motor vehicle use, especially on Spare the Air days
- Avoid using your wood stove and fireplace on days that have poor air quality
- Avoid using leaf blowers and other dust-producing equipment
- Drive slowly on unpaved roads and other dirt surfaces
- Get involved with air quality improvement programs in your community
- Avoid vigorous outdoor physical activity on days that have poor air quality
- If you own or operate a local source of PM emissions, comply with Air District rules that apply to your operation

For more information about particulate matter, please see these additional websites:

- [Information on SB 656](#)
- [EPA's PM standard attainment designations for the Western U.S.](#)
- [California's PM studies](#)
- [California's PM monitoring programs](#)
- [General particulate matter information at ARB](#)
- [General particulate matter information at EPA](#)
- [Health effects of PM](#)
- [CARB SB656 factsheet \(pdf\)](#)
- [SB 656 Particulate Matter Implementation Schedule \(pdf\)](#)
- [SB 656 Appendix B Response to Comments \(pdf\)](#)

Recent technical studies related to PM in the Bay Area can be found on the Air District's [Research & Modeling Publications](#) page.

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